


ESIF Technical Meeting

NREL/ESIF Fuel Cell & Hydrogen Capabilities

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Alliance for Sustainable Energy, LLC

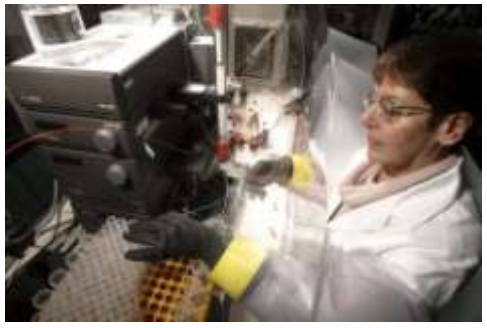
Bryan Pivovar
Acting Center Director – Hydrogen Technologies and Systems Center

Topics

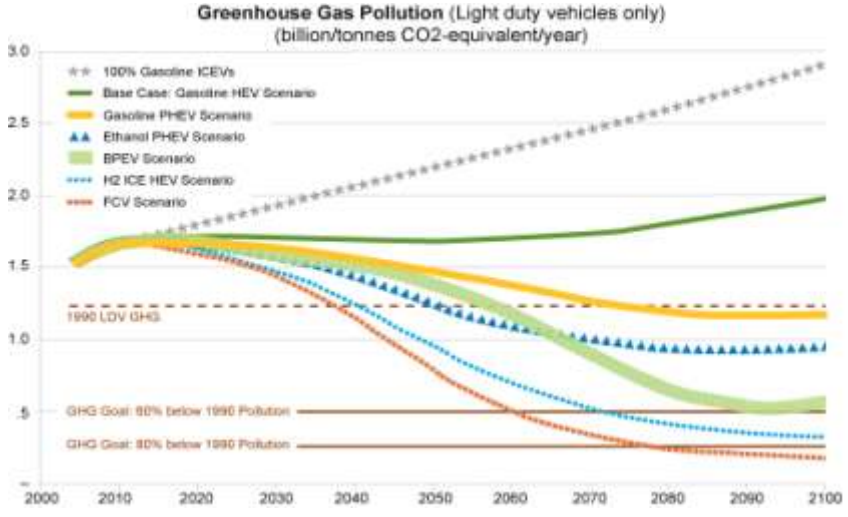
- U.S. DOE Program on Hydrogen & Fuel Cells
- NREL Hydrogen & Fuel Cell Technologies Program
- Current Capabilities
- ESIF Capabilities

U.S. & NREL Programs on Hydrogen & Fuel Cells

- Key drivers and potential
- DOE program direction, structure, and budgets
- NREL research scope
- NREL structure and budget
- NREL current collaborations



Potential Benefits–U.S. GHG Emissions



Source: Adapted from National Hydrogen Association (2009) from Dr. Sandy Thomas.

DOE Hydrogen/Fuel Cell RD&D Direction

Vision

A prosperous future for the nation, in which hydrogen energy and fuel cell power are clean, abundant, reliable, and affordable and are an integral part of all sectors of the economy in all regions of the country.

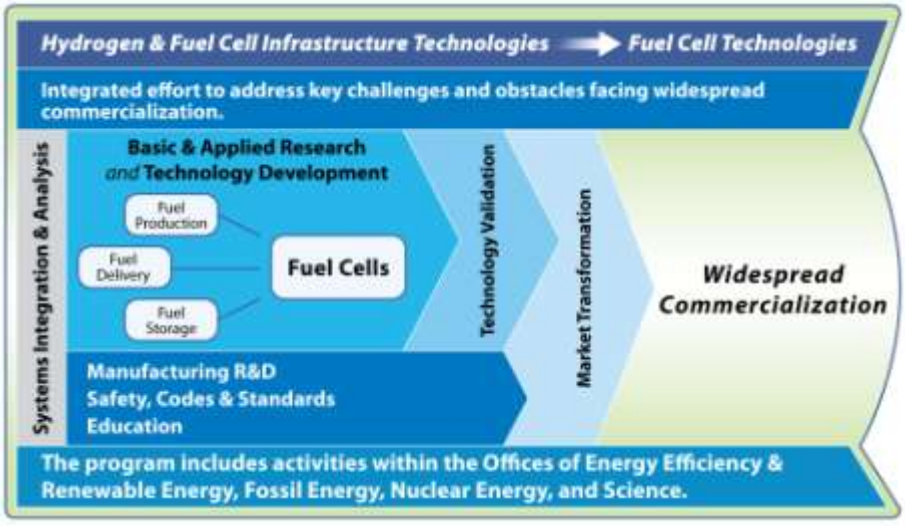
Mission

Research, develop, and validate fuel cells and hydrogen production, delivery, and storage technologies for transportation and stationary applications

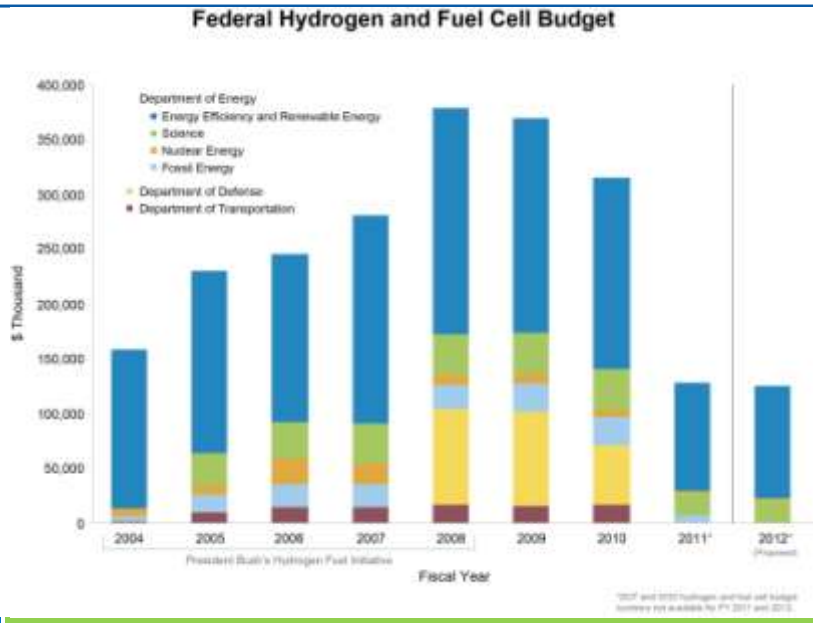
Key Goal

By 2015 develop and validate the readiness of technologies for producing, storing, and using hydrogen in fuel cells

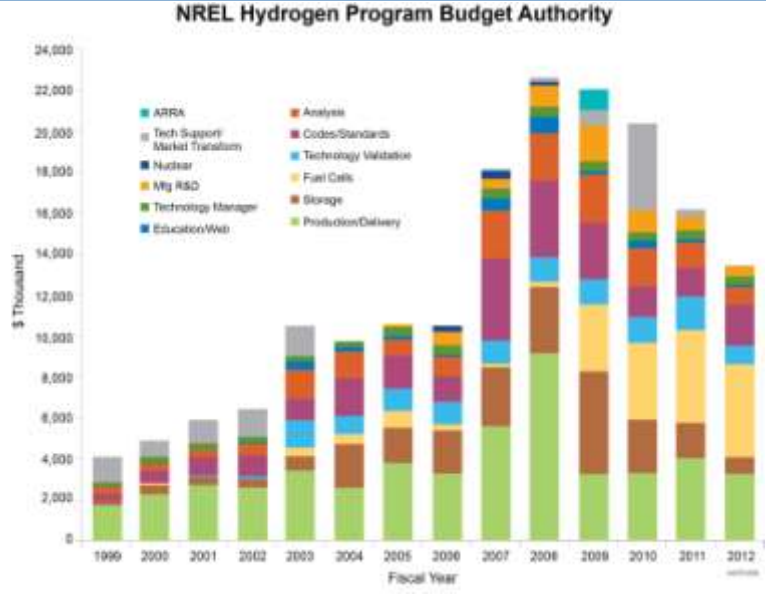
Fuel Cell Technologies Program Structure



Federal Hydrogen and Fuel Cell Budget



NREL FCHT Program Budget



NREL Fuel Cell & Hydrogen Technologies Program

- Renewable hydrogen production
- Hydrogen storage
- Fuel cell manufacturing
- Fuel cells
- Technology validation
- Safety, codes, & standards
- Analysis
- Market Transformation

NREL Collaborations

Partnerships help overcome barriers to our energy future powered by hydrogen and other clean, domestic resources.

University Collaborations

NREL H_2 Industry Partnerships

NREL - Federal Lab Partnerships

NREL Current Capabilities

Electrochemical Testing:

- Lab dedicated exclusively to electrochemical testing needs of fuel cell/electrolyzer materials.
- Capable of performing multiple electrochemical measurements including: ORR/MOR activity, ECSA, CV, LSV, potential cycling, impact of contaminants.
- 8 RDE/RRDE set-ups, multiple potentiostats for floating cell and half cell measurements.

NREL Current Capabilities

•***MEA and Electrode Fabrication*:**

- **Ultrasonic spraying of MEAs/Decals**
- **Handpainting, knife spreader, and spray coating capabilities for CCM and GDE fabrication**
- **Protocols for reproducible manufacturing and material preparation**
- **Equipment includes 12 ton hot press, high precision balances, gel dryer, hot plates, ultrasonicator, ultrasonic bath, stirrer, laser based thickness measurement, ultrasonic spray system, IR imaging for quality control, convection oven, fume hood, optical microscopes**

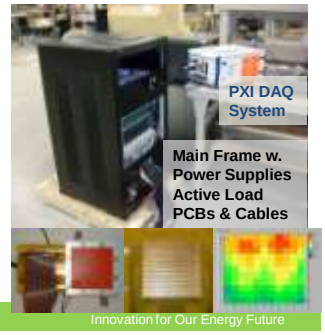
NREL Current Capabilities

Fuel Cell Testing:

- Twelve test stands offering 25 - 250 A range
- Testing capabilities include PEMFC, DMFC, PAFC (PBI), AEMFC, and SOFC
- Diagnostics include VI performance evaluation, H_2- and MeOH-crossover, cyclic voltammetry, AC impedance spectroscopy, HFR, overpotential separation, start/stop, contaminant effects, cycling, durability
- Capability for spatial measurements using 8-channel potentiostat or 121-channel segmented cell system (3M development)
- Calibration standards in accordance with or exceeding USFCC standards

NREL Fuel Cell Lab

NREL 121-Channel Segmented Cell

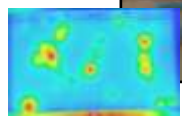


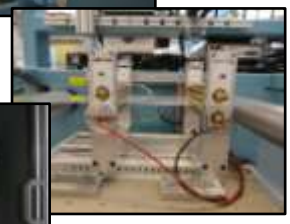
NREL Current Capabilities

Manufacturing:

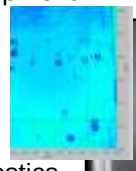
- Multiple diagnostic platforms for in-line quality control of MEAs and components:
  - Optical Reflectometry
  - Infrared
  - Laser
- Multiple scales for development and validation
  - Bench-top
  - Prototype
  - Pilot/Industrial
- Full suite of in-situ diagnostics to study the effects of as-manufactured defects, including segmented cell

Research Web-line





Bench-top Roller



Optical Prototype System

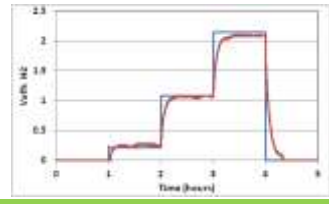
NREL Current Capabilities

H2 Sensors :

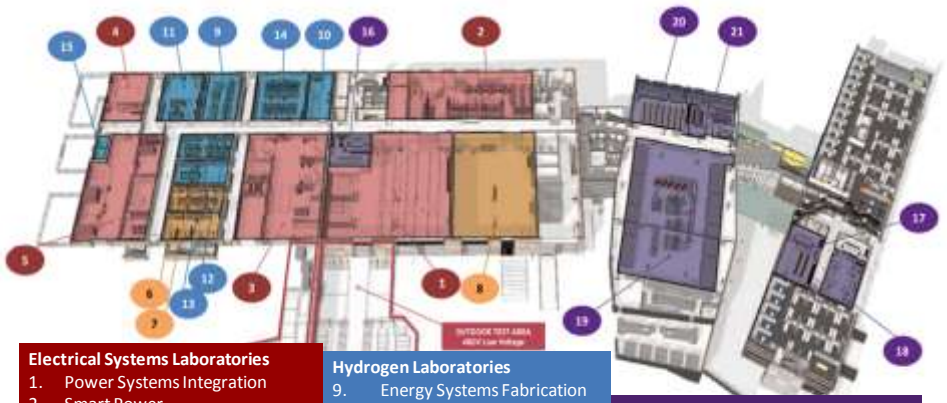
- Fully automated test apparatus, with “around-the-clock” operation
- Parallel testing of multiple sensors
- Full control and monitoring of gas parameters (flow, composition)
- Full control and monitoring of environmental parameters (T,P, RH)
- Standard but customizable protocols
- Validate sensor performance
  - Developers/Manufacturers
  - End-User

NREL Sensor Test Apparatus

Sensor response (–) to a H2 test gas (–)



ESIF Laboratories



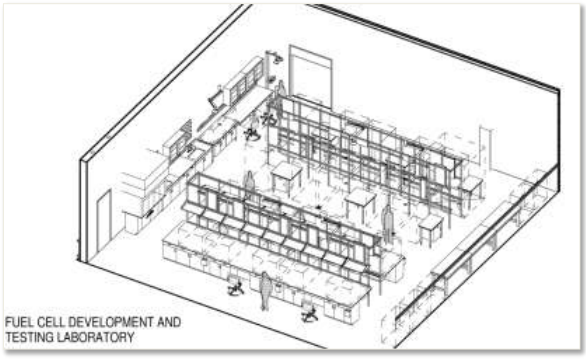
Electrical Systems Laboratories
1. Power Systems Integration
2. Smart Power
3. Energy Storage
4. Electrical Characterization
5. **Energy Systems Integration**

Thermal Systems Laboratories
6. Thermal Storage Process and Components
7. Thermal Storage Materials
8. Optical Characterization

Hydrogen Laboratories
9. Energy Systems Fabrication
10. Manufacturing
11. Materials Characterization
12. Electrochemical Characterization
13. Energy Systems Sensor
14. Fuel Cell Development & Test
15. Energy Systems High Pressure Test

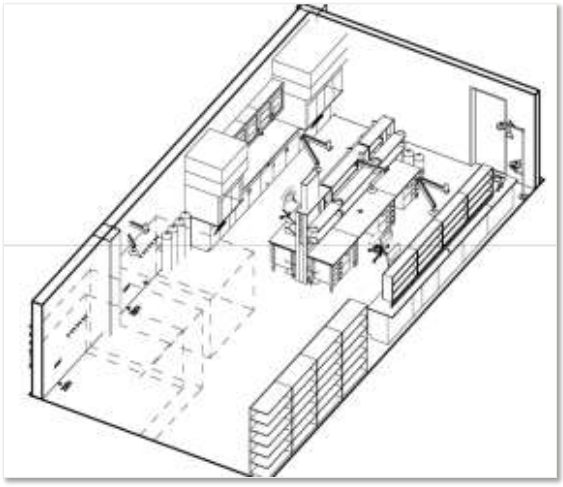
High Performance Computing, Data Analysis, and Visualization
16. ESIF Control Room
17. Energy Integration Visualization
18. **Secure Data Center**
19. High Performance Computing Data Center
20. Insight Center Visualization
21. Insight Center Collaboration

ESIF – Fuel Cell Development and Test Lab



- Largest single fuel cell test room in DOE complex.
- Benefits of co-location of test stands (manifolding, gases, plumbing, hardware, safety, and multi-tasking of equipment).
- Test capability to 200C.
- Test capability of stacks and short stacks, up to 6kW.
- Ventilated enclosure for use of high hazard gases.

ESIF – Energy Systems Sensor Lab



- Only lab of its kind dedicated to testing hydrogen safety sensors
- Will enable testing with flammable concentrations of H_2.
- High pressure testing (10000-psi)

Secure Data Center

Benefits

•Modern, professional workspace with room for expansion of capabilities.

•Secure meeting room for DOE and industry partners.

•Neutral analysis center and clearing house for industry lab and field data